Physics 320: Thermal Physics

Problem Set Assignments

Except where noted all problems are from Schroeder's text

PS #1: Due Wed. 11 January 2012

Calorimetry: 1.41, 1.47

Ideal Gas Law: 1.9, 1.11, 1.15, 1.16, 1.20, 1.23

Reversible thermodynamics processes with ideal gases: 1.31, 1.33, 1.34, 1.36, 1.37

PS #2: Due Fri. 20 January 2012

Heat engines: 4.20

I: Determine the work and the heat associated with each step in the Stirling cycle (two isotherms and two isochores). Derive an expression for the efficiency and compare it to the efficiency of the Carnot cycle operating between the same temperature extremes.

II. *Work this problem on your own. Do not collaborate with anyone else. This is an open-ended problem. Take it as far as you can in the time available.* Consider a three step reversible thermodynamic cycle as the basis for a heat engine. How efficient can you make it? Compare the efficiency to that of the Carnot cycle operating between the same two temperature extremes.

Classical entropy:

III. Consider a system with heat capacity C initially at temperature T_S that is put in thermal contact with a large reservoir at temperature T_R. Since the reservoir is so large, the final temperature of system, after thermal equilibration ends up being T_R (i.e. the reservoir's temperature does not change). Show that change in the total entropy cannot decrease independent of whether the initial temperature of the system is greater or less than that of the reservoir. What initial temperature of the system results in the smallest change in total entropy?

IV. A 50 Ω resistor starts at 300 K. How much does its entropy change when 2.5 A passes through it for 1 minute?

V. Use the thermodynamics identity and the ideal gas law to show that the entropy of an ideal gas can be written as

$$S = S_o + nC_V \ln T + nR \ln V,$$

Where S_o is the entropy of an arbitrary reference state of the gas.

Combinatorics: 2.3, 2.4 (also calculate the probability of being dealt a full house on the first deal),

V. *The meaning of never* (a problem from *Thermal* Physics, by Kittel and Kroemer): Suppose that 7×10^9 monkeys (approximately the human population on earth) have been seated at computer keyboards throughout the age of the universe (about 14 billion years) and that a given monkey can type 10 characters per second. Determine the probability that those monkeys will produce a particular sequence of approximately 10^5 characters corresponding to Shakespeare's *Hamlet* sometime since the Big Bang.

PS #3: Due Fri.30 January 2012

All problems for this set are from Schroeder's text.
CH 2: 6, 8, 12, 13, 14, 16, 37
CH 3: 19, 23, 36

PS #4: Due Wed. 15 February 2012

CH 6: 3, 5, 6, 11, 22, 37, 41
CH 7: 37, 43, 45, 52, 54

PS #5: Due Mon. 27 February 2012

CH 6: 42, 43
CH 7: 3, 6, 11, 12, 13, 18, 28, 33, 66, 67, 72

PS #6: Due Fri. 9 March 2012

CH 5: 22, 23, 32, 48, 51, 58, 62, 76

Work this problem on your own. Do not collaborate with anyone else. This is an open-ended problem. Take it as far as you can in the time available.
Consider a Carnot engine that uses a photon gas (cavity radiation) as its working substance. Work out expressions for each of the four steps (heat and work) in the Carnot cycle and the overall efficiency of the engine.